STANDARD
FOR
CHANNEL STABILIZATION

Definition

Stabilizing a channel, either natural or artificial, in which water flows with a free surface.

Purpose

Open channels are constructed or stabilized to be non-erodible and provide adequate capacity for the conveyance of flood water, drainage, other water management purposes or any combination thereof.

Conditions Where Practice Applies

This standard applies to the construction and stabilization of open channels for storm water conveyance and flood control and to the restoration of existing streams or ditches regardless of drainage area. It does not apply to diversions or grassed waterways.

Water Quality Enhancement

This standard seeks to produce a water conveyance channel which is characterized by natural features as much as possible while still incorporating engineered stability. This includes protection of existing vegetation and channel meander, rapid establishment of new stabilizing vegetation and design of new "natural" channel structures such as pools, riffles etc. Including these features helps promote low suspended solids, high dissolved oxygen levels and healthy macro invertebrate populations all of which are indicators of good water quality.

Design Criteria – Storm water conveyance and flood control channels

Planning

The alignment and design of channels shall involve giving careful consideration to the preservation of valuable fish and wildlife habitat. Trees of significant value for wildlife food or shelter shall be preserved whenever possible.

Where channel construction will adversely affect a significant fish or wildlife habitat, mitigation measures should be included in the plan. Mitigation measures may include pools, riffles, flats, cascades or other similar provisions.

As many trees as possible are to be left after considering the requirements for construction, operation and maintenance. See Standard for Tree Protection During Construction.

Realignment

The realignment of channels shall be kept to an absolute minimum.

Channel Capacity

The capacity for open channels shall be determined by the designer and/or the appropriate regulatory authority.

Capacity (peak discharge) shall be determined by the following methods:

1. Rational Method - for peak discharge of uniform drainage areas as outlined in Technical Manual for Stream Encroachment, Trenton, N.J., Bureau of Flood Plain Management,

2. USDA NRCS hydrologic procedures including WinTR55 and WinTR20.

3. U.S. Army Corps of Engineers HMS

4. Other methods which produce similar results to the models listed above.

Hydraulic Requirements

Manning's formula shall be used to determine the velocities in the channels.

The "n" values for use in this formula shall be estimated using currently accepted guides along with knowledge and experience regarding the conditions.

Acceptable guides can be found in Appendix A11, Refs. 6, 7, and Appendix A8.

Every reach shall be individually designed unless all reaches are designed on the worst cases for velocity and capacity (lowest allowable velocity, steepest slope).

Channel Side Slopes

Channel side slopes in earth shall be 2:1 or flatter unless the design, using the procedures in Appendix A8, shows that a steeper side slope is stable. Channel side slopes of materials other than earth shall be designed stable.

Channel Stability (General)

All channel construction, improvement and modification shall be in accord with a design which results in a stable channel.

Characteristics of a stable channel are:

1. It neither aggrades nor degrades beyond tolerable limits.

2. The channel banks do not erode to the extent that the channel cross section is changed appreciably.

3. Excessive sediment bars do not develop.

4. Excessive erosion does not occur around culverts and bridges or elsewhere.

5. Gullies do not form or enlarge due to the entry of uncontrolled surface flow to the channel.

The determination of channel stability considers bankfull flow. Bankfull flow is defined as the flow in the channel which creates a water surface that is at or near normal ground elevation for a significant length of a channel reach. Excessive channel depth created by cut through high ground, such as might result from realignment of the channel, should not be considered in determinations of bankfull flow.

Channel Stability (drainage area of one square mile or less)

1. Permanent Channel

   Channels in this category shall be considered stable if the actual velocity is less than the allowable velocities shown in Table 11-1. The actual velocity is defined as the velocity developed during the lesser of the following events:

   a. Bankfull discharge

b. 10-year frequency, storm, peak

2. Temporary (90 days or less) Bypass Channel

   Channels in this category shall be considered stable if the actual velocity is less than the allowable velocities shown in Table 11-1. The actual velocity is defined as the velocity developed during the 2-year frequency peak discharge.

3. As a stable design, the channel shall meet the following allowable velocity criteria and shall not be designed above 90% of critical flow (Froude number = 0.90).

Table 11-1
Allowable velocity for various soil textures

SOIL TEXTURE	ALLOWABLE VELOCITY ft./sec.
Sand	1.8
Sandy loam	2.5
Silt loam, loam	3.0
Sandy clay loam	3.5
Clay loam	4.0
Clay, fine gravel, graded loam to gravel	5.0
Cobbles	5.5
Shale (non weathered shale)	6.0

Linear crossing of existing channels by pipelines and similar devices do not require a stability analysis of the channel provided the final cross sectional area of the stream remains the same.

Channel Stability (drainage area greater than one square mile)

Channels must be stable under conditions existing immediately after construction (as-built condition) and under conditions existing during effective design life (aged condition). Channel stability shall be determined for discharges under these conditions as follows:

1. As-built condition - Bankfull flow, design discharge, or 10-year frequency flow, whichever is smallest, but not less than 50% of design discharge.

2. Aged condition - Bankfull flow or design discharge, whichever is larger, except that it is not necessary to check stability for discharges greater than the 100-year frequency.

Stability checks are not required if the actual velocity is 1.8 fps or less.

Linear crossing of existing channels by pipelines and similar devices do not require a stability analysis of the channel provided the final cross sectional area of the stream remains the same.

Where vegetation can be rapidly established by natural or artificial means, the allowable as-built velocity (regardless

of type stability analysis) in the newly constructed channel may be increased by a maximum of 20%. The 20% adjustment does not apply to the allowable velocity for aged condition. This increase is justified only if:

1. The soil and site in which the channel is to be constructed are suitable for rapid establishment and support of erosion-controlling vegetation,

2. Species of erosion-controlling vegetation adapted to the area and proven methods of establishment are known, and

3. The channel design includes detailed plans for establishing vegetation on the channel side slopes.

For newly constructed channels in fine-grained soils and sands, the "n" values shall be determined according to specifications in Appendix A8 and shall not exceed 0.025. The "n" value for channels to be modified by clearing and de-snagging only shall be determined by reaches according to the expected channel condition upon completion of the work.

The above stability checks will be made using either tractive stress or allowable velocity procedures given in Appendix A8. The choice of method will depend upon the grain size and cohesiveness of the soil being checked. The following will be used as a guide in choosing the method:

A. Tractive Stress - see Appendix A8

    1. Coarse grained soils

    2. Fine grained noncohesive soils (PI <10)

B. Allowable Velocity - see Appendix A8

    1. Coarse grained soils (tractive stress procedure recommended)

    2. Fine grained cohesive soils (PI >10)

    3. Fine grained noncohesive soils (PI <10) (tractive stress procedure recommended)

Stability checks should be made for each significant soil horizon present. Soil sampling and testing is required to determine the grain size distribution and plasticity index of each material to be checked.

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<u>Channel Linings and Structural Measures</u>

Where channel velocities exceed allowable velocities, the channel must be stabilized.

Channels may be stabilized by using one or more of the following methods:

1. <u>Rock Riprap Lining</u> shall be designed using the procedures given in Standard for Riprap, p. 23-1.

2. <u>Concrete Lining</u> shall be designed according to currently accepted guides for structural and hydraulic adequacy. They must be designed to carry the required discharge and to withstand the loading imposed by site conditions. Concrete lining shall be reinforced where required.

3. <u>Grade Stabilization Structures</u> can be used where excessive grades exist. The structures provide for one or more drops along the channel profile to reduce the channel slope. See Standard for Grade Stabilization

Structures.

The structures must be designed hydraulically to adequately carry the channel discharge and structurally to withstand loadings imposed by the site conditions. They may be constructed of concrete, rock, masonry, steel, gabions, aluminum or treated timber. Appendix A11, Chapter 6, Ref. #8, provides procedures for use in the design of these structures.

Energy Dissipaters are employed to force a hydraulic jump and its associated turbulence to occur at a location where suitable protection can be provided against bank scour and channel erosion. Construction of energy dissipaters are normally at the base of chutes or drop structures and are usually an integral part of the design of the structure. Sills, baffles, floor blocks or other obstructions to channel flow may serve as energy dissipaters.
Appendix A11, Chapter 15, Ref. #6, provides design considerations for energy dissipation with the hydraulic jump.

4. Consideration may be given to the utilization of Soil Bioengineering techniques for channel stabilization. These techniques are not to be used when a structural design is required for safety, etc. See Standard for Soil Bioengineering for additional design guidance.

Design Criteria – Stream Restoration

Designs for stream restoration try to mimic natural conditions present in stable reaches proximate to the area to be treated. The extent of structural treatments beyond toe protection will be evaluated on a case by case basis. Generally, vegetative or bioengineering treatments (Soil Bioengineering) shall be used to stabilize low risk areas (agricultural, wooded, or other natural settings where there is little threat to adjacent structures or improvements. In high risk areas where there is significant threat of damage to physical improvements (homes, buildings, utilities, roadways, etc.) or to important cultural or environmental features, structural protection will be more appropriate.

A site assessment shall be performed to determine if the causes of instability are local (e.g. poor soils, high water table in banks, alignment, obstructions deflecting flows into bank, etc.) or systemic in nature (e.g. aggradation due to increased sediment from the watershed, increased runoff due to urban development in the watershed, degradation due to channel modifications, etc.). The assessment need only be of the extent and detail necessary to provide a basis for design of the treatments and reasonable confidence that the treatments will perform adequately for the design life of the measure.

In low risk areas treatments shall be evaluated under bankfull or ten-year return period (10 percent probability) flow conditions, whichever is less. High risk areas may require evaluations under less frequent flow events (up to a 100 year return period) depending on the value of the protected area. More frequent storm events should also be evaluated where these result in higher flow velocities.

Changes in channel alignment shall not be made without an assessment of both upstream and downstream fluvial geomorphology that evaluates the affects of the proposed alignment. The current and future discharge-sediment regime shall be based on an assessment of the watershed above the proposed channel alignment.

Bank protection treatment shall not be installed in channel systems undergoing rapid and extensive changes in bottom grade and/or alignment unless the treatments are designed to control or accommodate the changes. Bank treatment shall be constructed to a depth at or below the anticipated lowest depth of streambed scour.

Toe erosion shall be stabilized by treatments that redirect the stream flow away from the toe or by structural treatments that armor the toe. Additional design guidance is found in the National Engineering Handbook Part 654, Stream Restoration Design. Where toe protection alone is inadequate to stabilize the bank, the upper bank shall be shaped to a stable slope and vegetated, or shall be stabilized with structural or soil-bioengineering treatments. Measures to redirect flow shall not reduce the flood carrying capacity of the stream nor cause adverse erosion or sedimentation elsewhere in the stream system. All treatments shall be stable under design flow conditions.

Where flooding is a concern, the effects of protective treatments shall not increase flow levels above those that existed prior to installation. When vegetative treatments are planned, flow levels shall be evaluated under mature growth conditions.

Installation Requirements

1. All trees, brush, stumps, and other objectionable materials that would interfere with the construction or proper functioning of the channel shall be removed.

2. Where possible, trees will be left standing, brush and stumps will not be removed and channels will be excavated from one side, leaving vegetation on the opposite side.

3. Construction plans will specifically detail the location and handling of spoils.

4. Seeding, fertilizing and mulching shall conform to the Standard for Permanent Vegetative Cover for Soil Stabilization.

5. Vegetation shall be established on all disturbed areas immediately after construction, weather permitting. If weather conditions are such as to cause a delay in the establishment of vegetation the area shall be mulched in accordance with the Standard for Stabilization with Mulch Only.